CLAIMS

1. An apparatus comprising:

a two-dimensional (2D) array transducer transmitting ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue.

2. An apparatus as in claim 1, wherein the array transducer includes a total number of elements of which at least 25% are excited to transmit the ultrasonic energy.

3. An apparatus as in claim 1, further comprising:

transmit beamforming electronics including a high voltage circuit driving the array transducer to transmit the ultrasonic energy.

4. An apparatus as in claim 1, further comprising:

a high voltage field effect transistor (FET) driving the array transducer to transmit the ultrasonic energy.

5. An apparatus as in claim 1, further comprising:

means for driving the array transducer with a high voltage to transmit the ultrasonic energy.

6. An apparatus as in claim 1, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

a high impedance backing for the piezoelectric elements.

7. An apparatus as in claim 1, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

means for providing a high impedance backing for the piezoelectric elements.

8. An apparatus as in claim 1, wherein the array transducer is constructed of materials comprising a single crystal.

9. An apparatus as in claim 1, wherein the array transducer is constructed of a plurality of piezoelectric elements of a single crystal.

10. An apparatus as in claim 1, wherein the array transducer transmits the ultrasound energy with a waveform having a bandwidth BW greater than or equal to 60% of the fundamental frequency, where $BW = (f_B - f_A)$, f_B is a higher frequency than the fundamental frequency at a power level 6 dB lower than at the fundamental frequency,

f_A is a lower frequency than the fundamental frequency at a power level 6 dB lower than the fundamental frequency.

11. An apparatus as in claim 1, wherein the array transducer transmits the ultrasonic energy at a sufficient power to generate a second harmonic in the tissue having a maximum power level of less than 15 dB from the maximum power level of the fundamental frequency in the tissue.

12. An apparatus as in claim 1, wherein the array transducer has a checkerboard pattern formed by a plurality of elements, each element used for either transmit or receive.

13. An apparatus as in claim 1, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements being used to transmit and a plurality of the elements used to receive.

14. An apparatus as in claim 1, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics to transmit the ultrasonic energy, and a plurality of the elements connected to low-voltage electronics to receive the generated harmonic.

15. An apparatus as in claim 1, wherein the array transducer is formed by a plurality of elements in an alternating transmit-receive checkerboard pattern.

16. An apparatus as in claim 1, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the high voltage circuit including a high-voltage FET, the low-voltage circuit and the high-voltage circuit being monolithically formed on a single substrate.

17. An apparatus as in claim 1, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the low-voltage circuit and the high-voltage circuit being formed on a single substrate.

18. An apparatus as in claim 1, further comprising:

means for providing a low-voltage circuit and a high-voltage circuit both formed on the same single substrate, the high-voltage circuit for driving the array transducer to transmit the ultrasonic energy.

19. An apparatus comprising:

a two-dimensional (2D) array transducer comprising a total number of piezoelectric elements of which at least 25% are excited to transmit ultrasonic energy in tissue at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue.

20. An apparatus as in claim 19, further comprising:

a high voltage field effect transistor (FET) driving the excited piezoelectric elements to transmit the ultrasonic energy.

21. An apparatus as in claim 19, further comprising:

means for driving the excited piezoelectric elements with a high voltage to transmit the ultrasonic energy.

22. An apparatus as in claim 19, further comprising:

a high impedance backing for the piezoelectric elements.

23. An apparatus as in claim 19, further comprising:

means for providing a high impedance backing for the piezoelectric elements.

24. An apparatus as in claim 20, further comprising:

a high impedance backing for the piezoelectric elements.

25. An apparatus as in claim 19, wherein the piezoelectric elements are of a single crystal.

26. An apparatus as in claim 20, wherein the piezoelectric elements are of a single crystal.

27. An apparatus as in claim 22, wherein the piezoelectric elements are of a single crystal.

28. An apparatus as in claim 19, wherein the array transducer transmits the ultrasound energy with a waveform having a bandwidth BW greater than or equal to 60% of the fundamental frequency, where $BW = (f_B - f_A)$, f_B is a higher frequency than the fundamental frequency at a power level 6 dB lower than at the fundamental frequency,

f_A is a lower frequency than the fundamental frequency at a power level 6 dB lower than the fundamental frequency.

29. An apparatus as in claim 19, wherein the array transducer transmits the ultrasonic energy at a sufficient power to generate a second harmonic in the tissue having a maximum power level of less than 15 dB from the maximum power level of the fundamental frequency in the tissue.

30. An apparatus as in claim 19, wherein the piezoelectric elements are in a checkerboard pattern, each piezoelectric element used for either transmit or receive.

31. An apparatus as in claim 19, wherein the excited piezoelectric elements are connected to high-voltage electronics to transmit the ultrasonic energy, and a plurality of the remaining piezoelectric elements are connected to low-voltage electronics to receive the generated harmonic.

32. An apparatus as in claim 19, wherein the piezoelectric elements are arranged in an alternating transmit-receive checkerboard pattern.

33. An apparatus as in claim 19, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the excited piezoelectric elements to transmit the ultrasonic energy, the low-voltage circuit and the high-voltage circuit being formed on a single substrate.

34. An apparatus as in claim 19, further comprising:means for providing a low-voltage circuit and a high-voltage circuit both formed on the same single substrate, the high-voltage circuit for driving the excited piezoelectric elements to transmit the ultrasonic energy.

35. An apparatus comprising:

a transducer handle positionable near tissue, the handle external to ultrasound processing equipment producing control signals for ultrasound imaging;

at least some transmit beamforming electronics housed in the handle and generating excitation signals in accordance with the control signals; and

a two-dimensional (2D) array transducer housed in the handle and, in accordance with the excitations signals, transmitting ultrasonic energy in tissue at a fundamental

frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue.

36. An apparatus as in claim 35, wherein the array transducer includes a total number of elements of which at least 25% are excited to transmit the ultrasonic energy.

37. An apparatus as in claim 35, further comprising:

a high voltage circuit driving the array transducer to transmit the ultrasonic energy and housed in the handle.

38. An apparatus as in claim 35, further comprising:

a high voltage field effect transistor (FET) driving the array transducer to transmit the ultrasonic energy and housed in the handle.

39. An apparatus as in claim 35, further comprising:

means for driving the array transducer with a high voltage to transmit the ultrasonic energy, said means being housed in the handle.

40. An apparatus as in claim 35, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

a high impedance backing for the piezoelectric elements and housed in the handle.

41. An apparatus as in claim 35, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

means for providing a high impedance backing for the piezoelectric elements, said means being housed in the handle.

42. An apparatus as in claim 35, wherein the array transducer is constructed of materials comprising a single crystal.

43. An apparatus as in claim 35, wherein the array transducer is constructed of a plurality of piezoelectric elements of a single crystal.

44. An apparatus as in claim 35, wherein the array transducer transmits the ultrasound energy with a waveform having a bandwidth BW greater than or equal to 60% of the fundamental frequency, where $BW = (f_B - f_A)$, f_B is a higher frequency than the fundamental frequency at a power level 6 dB lower than at the fundamental frequency, f_A is a lower frequency than the fundamental frequency at a power level 6 dB lower than the fundamental frequency.

45. An apparatus as in claim 35, wherein the array transducer transmits the ultrasonic energy at a sufficient power to generate a second harmonic in the tissue having a maximum power level of less than 15 dB from the maximum power level of the fundamental frequency in the tissue.

46. An apparatus as in claim 35, wherein the array transducer has a checkerboard pattern formed by a plurality of elements, each element used for either transmit or receive.

47. An apparatus as in claim 35, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements being used to transmit and a plurality of the elements used to receive.

48. An apparatus as in claim 35, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics to transmit the ultrasonic energy, and a plurality of the elements connected to low-voltage electronics to receive the generated harmonic.

49. An apparatus as in claim 35, wherein the array transducer is formed by a plurality of elements in an alternating transmit-receive checkerboard pattern.

50. An apparatus as in claim 35, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the high voltage circuit including a high-voltage FET, the low-voltage circuit and the high-voltage circuit being monolithically formed on a single substrate and being housed in the handle.

51. An apparatus as in claim 35, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the low-voltage circuit and the high-voltage circuit being formed on a single substrate and being housed in the handle.

52. An apparatus as in claim 35, further comprising:

means for providing a low-voltage circuit and a high-voltage circuit both formed on the same single substrate, the high-voltage circuit for driving the array transducer to transmit the ultrasonic energy, said means being housed in the handle.

53. An apparatus as in claim 35, further comprising:

a communication channel connecting the handle to the ultrasound processing equipment to allow the control signals produced by the electronic processing equipment to be provided to the beamforming electronics in the handle.

54. An apparatus as in claim 53, wherein the communication channel is one of the group consisting of a cable and a wireless communications channel.

55. An apparatus comprising:

electronic processing equipment producing control signals for ultrasound imaging;

a handle extèrnal to the electronic processing equipment and positionable near tissue;

at least some transmit beamforming electronics housed in the handle;

a communication channel connecting the electronic processing equipment to the transmit beamforming electronics in the handle so that the transmit beamforming electronics generates excitation signals in accordance with the control signals produced by the electronic processing equipment; and

a two-dimensional (2D) array transducer housed in the handle and, in accordance with the excitation signals, transmitting ultrasonic energy in tissue near which the handle is positioned at a fundamental frequency and of sufficient power to generate a harmonic of the fundamental frequency in the tissue.

56. An apparatus as in claims 55, wherein the array transducer receives the generated harmonic, the apparatus further comprising:

at least some receive beamforming electronics housed in the handle and processing the received harmonic, the receive beamforming electronics connected to the electronic processing equipment by the communication channel to allow the electronic processing equipment to display an ultrasonic image on a display in accordance with the harmonic processed by the receive beamforming electronics.

57. An apparatus as in claim 55, wherein the array transducer includes a total number of elements of which at least 25% are excited to transmit the ultrasonic energy.

58. An apparatus as in claim 55, further comprising:

a high voltage circuit driving the array transducer to transmit the ultrasonic energy and housed in the handle.

59. An apparatus as in claim 55, further comprising:

a high voltage field effect transistor (FET) driving the array transducer to transmit the ultrasonic energy and housed in the handle.

60. An apparatus as in claim 55, further comprising:

means for driving the array transducer with a high voltage to transmit the ultrasonic energy, said means being housed in the handle.

61. An apparatus as in claim 55, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

a high impedance backing for the piezoelectric elements and housed in the handle.

62. An apparatus as in claim 55, wherein the array transducer includes a plurality of piezoelectric elements forming the array transducer, the apparatus further comprising:

means for providing a high impedance backing for the piezoelectric elements, said means being housed in the handle.

63. An apparatus as in claim 55, wherein the array transducer is constructed of materials comprising a single crystal.

64. An apparatus as in claim 55, wherein the array transducer is constructed of a plurality of piezoelectric elements of a single crystal.

65. An apparatus as in claim 55, wherein the array transducer transmits the ultrasound energy with a waveform having a bandwidth BW greater than or equal to 60% of the fundamental frequency, where $BW = (f_B - f_A)$, f_B is a higher frequency than the fundamental frequency at a power level 6 dB lower than at the fundamental frequency, f_A is a lower frequency than the fundamental frequency at a power level 6 dB lower than the fundamental frequency.

66. An apparatus as in claim 55, wherein the array transducer transmits the ultrasonic energy at a sufficient power to generate a second harmonic in the tissue having a

maximum power level of less than 15 dB from the maximum power level of the fundamental frequency in the tissue.

67. An apparatus as in claim 55, wherein the array transducer has a checkerboard pattern formed by a plurality of elements, each element used for either transmit or receive.

68. An apparatus as in claim 55, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements being used to transmit and a plurality of the elements used to receive.

69. An apparatus as in claim 55, wherein the array transducer has a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics in the handle to transmit the ultrasonic energy, and a plurality of the elements connected to low-voltage electronics in the handle to receive the generated harmonic.

70. An apparatus as in claim 55, wherein the array transducer is formed by a plurality of elements in an alternating transmit-receive checkerboard pattern.

71. An apparatus as in claim 55, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the high voltage circuit including a high-voltage FET, the low-voltage circuit and the high-voltage circuit being monolithically formed on a single substrate and being housed in the handle.

72. An apparatus as in claim 55, further comprising:

a low-voltage circuit; and

a high-voltage circuit driving the array transducer to transmit the ultrasonic energy, the low-voltage circuit and the high-voltage circuit being formed on a single substrate and being housed in the handle.

73. An apparatus as in claim 55, further comprising:

means for providing a low-voltage circuit and a high-voltage circuit both formed on the same single substrate, the high-voltage circuit for driving the array transducer to transmit the ultrasonic energy, said means being housed in the handle.

74. An apparatus as in claim 55, wherein the communication channel is one of the group consisting of a cable and a wireless communications channel.

75. An apparatus comprising:

an array transducer having a checkerboard pattern formed by a plurality of elements, each element used to either transmit ultrasonic energy at a fundamental frequency or receive a signal generated in tissue by the transmitted ultrasonic energy.

76. An apparatus comprising:

an array transducer having a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements used to transmit ultrasonic energy at a fundamental frequency, and a plurality of the elements used to receive a signal generated in tissue by the transmitted ultrasonic energy.

77. An apparatus comprising:

an array transducer having a checkerboard pattern formed by a total number of elements, at least 25% of the total number of elements connected to high-voltage electronics to transmit ultrasonic energy at a fundamental frequency, and a plurality of the elements connected to low-voltage electronics to receive a signal generated in tissue by the transmitted ultrasonic energy.

78. An apparatus comprising:

an array transducer having a checkerboard pattern formed by a plurality of elements in an alternating transmit-receive checkerboard pattern, where transmitting elements transmit ultrasonic energy at a fundamental frequency and receiving elements receive a signal generated in tissue by the transmitted ultrasonic energy.